

**AD821651**

**MECHANICAL-PROPERTY DATA  
HP 9Ni-4Co-45C  
STEEL**

**Tempered Forging**

**Issued by**

**Air Force Materials Laboratory  
Research and Technology Division  
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#### HP 9-4-45

The HP 9-4-45 alloy is a nickel-cobalt steel developed specifically to have high hardenability and good toughness. A quench and temper heat treatment may be used for sheet and thin sections to produce a tempered martensitic structure. An alternate heat treatment that results in a bainitic structure increases the section size that can be hardened. The bainitic treatment increases the toughness for all product forms.

This alloy is intended to be fabricated in the annealed condition. It can be TIG welded in the annealed condition but requires post treatment to achieve high joint efficiencies.

HP 9-4-45 is available as sheet, plate, bar, and forgings.

HP 9-4-45 Data(a)

Condition: Bainitic(b)  
Thickness: 2-1/2 in. Forging

Properties	Temperature, F		
	RT	300	500
<u>Tension</u>			
F <sub>tu</sub> (longitudinal), ksi	266	272	237
F <sub>tu</sub> (transverse), ksi	265	272	241
F <sub>tu</sub> (short transverse), ksi	266	--	--
F <sub>ty</sub> (longitudinal), ksi	220	196	171
F <sub>ty</sub> (transverse), ksi	220	196	170
F <sub>ty</sub> (short transverse), ksi	220	--	--
e <sub>t</sub> (longitudinal), percent in 2 in.	14.0	16.7	18.5
e <sub>t</sub> (transverse), percent in 2 in.	10.5	12.5	17.8
e <sub>t</sub> (short transverse), percent in 2 in.	13.3	--	--
RA (longitudinal), percent	54.8	55.2	69.7
RA (transverse), percent	40.2	35.7	56.2
E <sub>t</sub> (longitudinal), 10 <sup>6</sup> psi	27.9	26.6	24.4
E <sub>t</sub> (longitudinal), 10 <sup>6</sup> psi	27.6	26.6	24.8
<u>Compression</u>			
F <sub>cy</sub> (longitudinal), ksi	246	211	184
F <sub>cy</sub> (transverse), ksi	245	216	182
E <sub>c</sub> (longitudinal), 10 <sup>6</sup> psi	30.1	27.4	26.9
E <sub>c</sub> (transverse), 10 <sup>6</sup> psi	30.1	27.8	26.6
<u>Shear</u> <sup>(d)</sup>			
F <sub>su</sub> (longitudinal), ksi	161.2	U <sup>(c)</sup>	U
F <sub>su</sub> (transverse), ksi	161.5	U	U
<u>Impact</u> (V-notch Charpy), ft-lb			
	16-22 <sup>(e)</sup>	U	U
<u>Fracture Toughness</u> , K <sub>IC</sub> , ksi√in.			
	46.0 <sup>(f)</sup>	U	U

Properties	Temperature, F		
	RT	300	500
<u>Axial Fatigue (transverse)(g)</u>			
Unnotched, R = 0.1			
10 <sup>3</sup> cycles, ksi	266	266	266
10 <sup>5</sup> cycles, ksi	185	164	157
10 <sup>7</sup> cycles, ksi	150	130	110
Notched (K <sub>t</sub> = 3.0), R = 0.1			
10 <sup>3</sup> cycles, ksi	205	200	188
10 <sup>5</sup> cycles, ksi	72	65	60
10 <sup>7</sup> cycles, ksi	50	50	50
<u>Creep and Stress Rupture</u>	NA <sup>(c)</sup>	NA	(h)
<u>Stress Corrosion</u>			
80% F <sub>ty</sub> , 1000 hr max.	No cracks <sup>(i)</sup>	U	U
<u>Coefficient of Thermal Expansion<sup>(e)</sup></u>			
68 to 800 F	6.2 x 10 <sup>-6</sup> in./in./F		
<u>Density<sup>(j)</sup></u>	0.28 lb/in. <sup>3</sup>		

(a) Data are average of triplicate tests conducted at Battelle under the subject contract unless otherwise indicated. Fatigue, creep, and stress-rupture values are from data curves generated using the results of a greater number of tests.

(b) Treatment: 1 hr at 1600 F, AC; 1 hr at 1475 F, quench in salt at 475 F; 6 hr at 475 F.

(c) U, unavailable; NA, not applicable.

(d) Double shear (1/4-inch pin).

(e) Values from Reference U.

(f) Fatigue-cracked single-edge-notched slow-bend specimen (1" x 2" x 18") tested under four-point loading. Pop-in detected by means of a strain gage mounted on the specimen opposite the fatigue crack.

(g) "R" represents the algebraic ratio of the minimum stress to the maximum stress in one cycle; that is,  $R = S_{min} / S_{max}$ . "K<sub>t</sub>" represents the Neuber-Peterson theoretical stress-concentration factor.

(h) Material did not go to 0.1% elongation or to rupture at 500 F when stressed to the tensile yield strength level.

(i) Alternate immersion, 3-1/2% NaCl. Three-point loading bend test.

(j) Value from Reference (2).

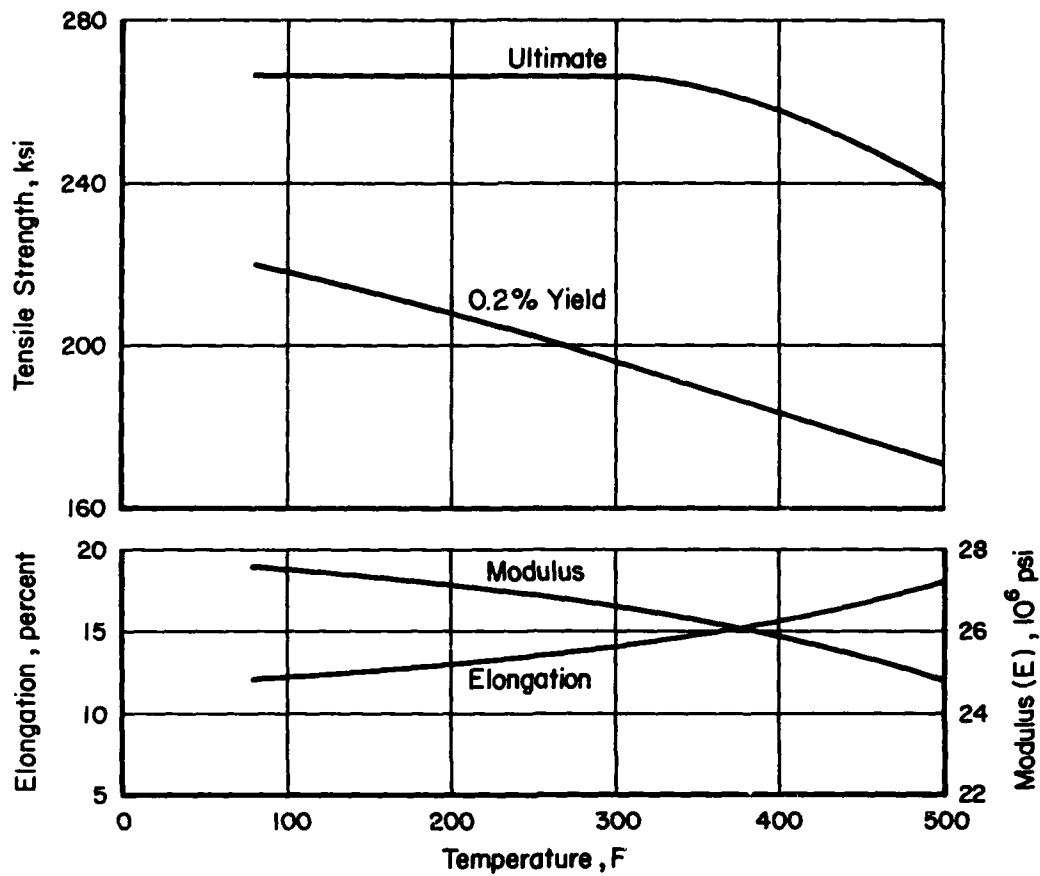


FIGURE 1. EFFECT OF TEMPERATURE ON THE TENSILE PROPERTIES OF HP 9-4-45 FORGINGS

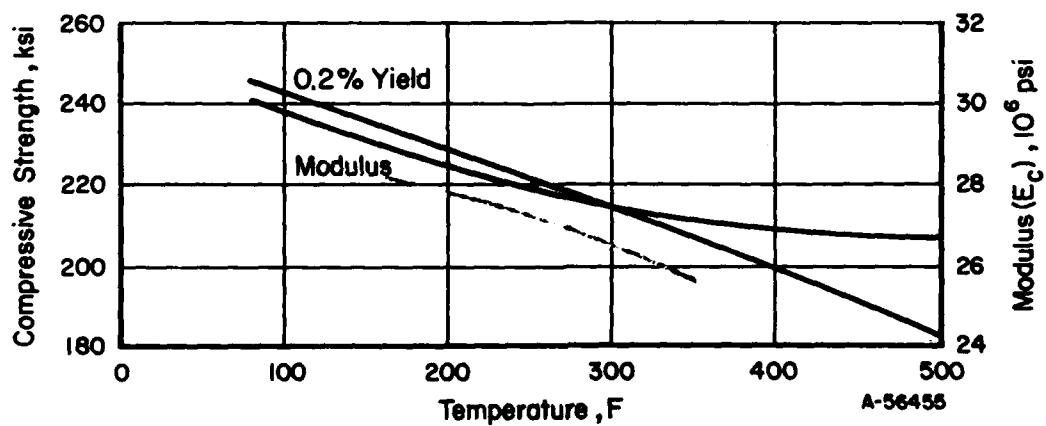


FIGURE 2. EFFECT OF TEMPERATURE ON THE COMPRESSIVE PROPERTIES OF HP 9-4-45 FORGINGS

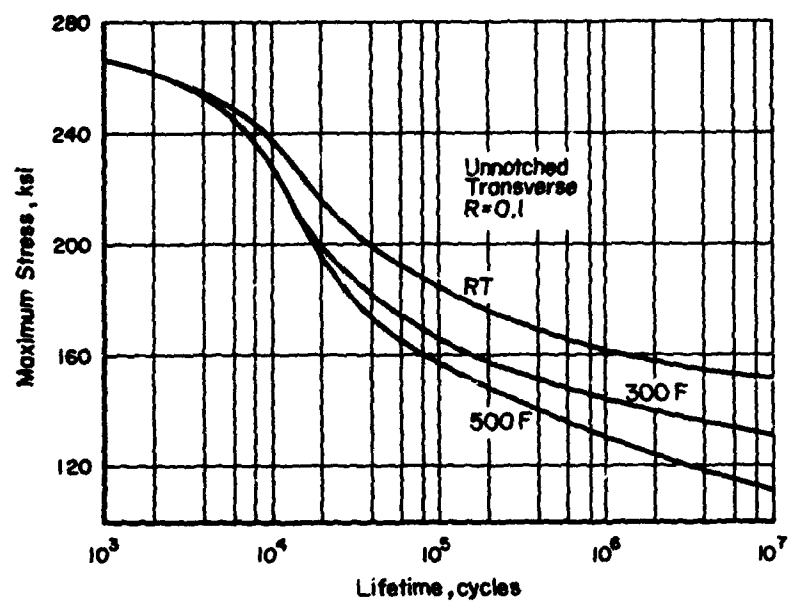


FIGURE 3. AXIAL LOAD FATIGUE RESULTS FOR HP 9-4-45 FORGINGS AT THREE TEMPERATURES

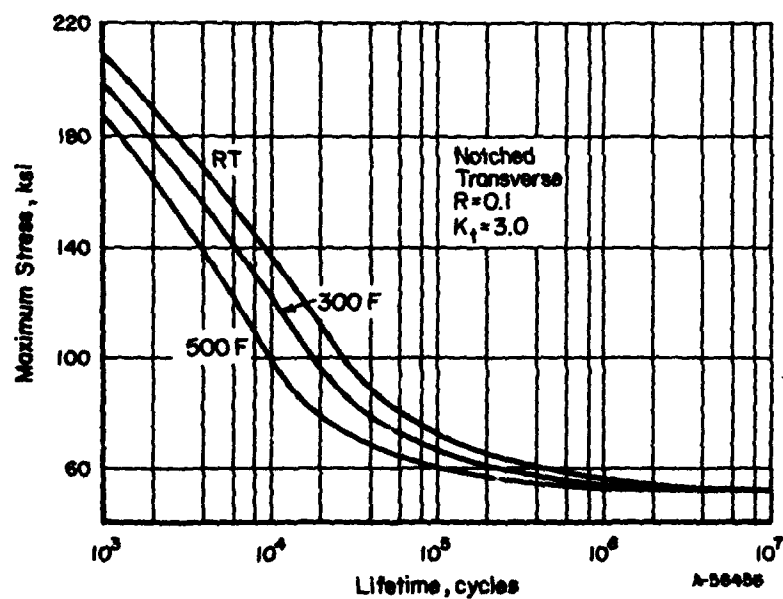


FIGURE 4. AXIAL LOAD FATIGUE RESULTS FOR NOTCHED ( $K_t = 3.0$ ) HP 9-4-45 FORGINGS AT THREE TEMPERATURES

#### REFERENCES

- (1) Pascover, J. S., and Matas, A. J., "Properties of HP 9-4-X Alloy Steels", WADC TDR 64-225 (1964).
- (2) "Preliminary Technical Data on the Republic Hi Performance Steels", Republic Steel Brochure.